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THE TEA RESEARCH INSTITUTE,
St. Coombs, Talawakelle,
Ceylon.

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General.—The laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries there should be addressed to the Director Tea Research Institute, Talawakelle. Telegraphic address : RESEARCH, TALAWAKELLE, Telephone : Talawakelle 44 (Private Exchange).

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NOTICE

There is a big demand for back numbers of the *Tea Quarterly* and *Bulletin* of the Tea Research Institute by local planters and proprietors of tea estates. Stocks of some back numbers of these publications are exhausted and it will be appreciated if subscribers and recipients of publications through our free mailing list will return any duplicates of back publications which are surplus to their requirements. Postage will be reimbursed on request.

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THE TEA QUARTERLY

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STORAGE OF TEA SEED

P. F. Hume

(Chapelton Estate, Bogawantalawa)

These pioneer experiments of Mr. Hume, in which he has demonstrated that tea seed can be successfully kept in cold storage at 40°F for periods of up to six months without loss of germination, should prove of the greatest value to all tea seed producers.

It must frequently happen on estates where tea seed is sold in large quantities, say 150 to 200 maunds a year, that it is not always possible to dispose of the total harvested crops, particularly during the heavy cropping months. On this particular estate nearly 3/5 of the annual crop is harvested during the period June/September. It may be that for one reason or another there is no demand for seed or it may be that monthly crops, which can not always be accurately estimated, greatly exceed expectations and buyers are not to be found at short notice to purchase these few additional maunds. On the other hand it must frequently happen that the supplier has to refuse numerous requests for tea seed during the period October/May as seed at that particular time of year is in short supply but in strong demand. This has certainly been my experience on Chapelton in 3 out of the 7 years that I have been in charge of this estate. To my knowledge, 2 years ago, on an estate which sells some 200 maunds of tea seed a year, 40 odd maunds of seed had to be thrown away during July, August and September, because unexpectedly good seed crops were harvested, and there was at that time very little demand for seed. If that seed could have been stored for say 2 to 6 months I have no doubt at all that it could have been disposed of to the mutual benefit of supplier and purchaser. I have been involved in a similar situation more than once but fortunately not involving so great a quantity of seed.

As a result of this experience I began to make extensive enquiries on the storage of tea seed. The only information and advice I was able to obtain was to store seed in air tight containers, *i.e.* kerosene oil tins or larger containers depending on the quantity of surplus seed involved. This was tried out with several maunds of seed packed with or without charcoal, in kerosene oil tins, in lined tea chests and so on. The results even after only 2 and 3 months storage were extremely disappointing; no seed stored in such a manner could be sold, since even 50 per cent. germination could not be guaranteed after 3 months storage.

It then occurred to me that most vegetables, fruits, etc. can be, and are, stored for considerable periods of time in a deep freeze; why then should tea seed not be similarly stored? I therefore wrote to the T.R.I. asking their advice and views on this idea. Mr. Portsmouth was enthusiastic and immediately wrote giving me temperatures at which this experiment might be tried out which were briefly as follows:—

(1) Tea seed stored in sealed tins with charcoal at a constant temperature of 20°F.

(2) Tea seed stored in wooden boxes, lined with paper, but naturally not air tight, at 40°F.

Unfortunately I had at this particular time very little surplus seed and I was therefore only able to pack 5 wooden boxes, each containing $\frac{1}{2}$ maund seed, and 2 kerosene oil tins, each containing 29 lbs. (This was the total amount of seed which could be put into one kerosene oil tin). The seed was carefully selected. Each $\frac{1}{2}$ maund box contained approximately 8,500 seeds: a more normal quantity would have been from 10,000 to 12,000 seeds. Before despatch the seed was "floated", and seed which sank within 5 minutes was then put in the sun for 5 minutes before being packed. The containers were numbered and dated and sent down to the Cold Stores Ltd., Colombo for storage at the recommended temperatures. The containers were withdrawn from Cold Stores for germination tests after periods of 1, 3, $4\frac{1}{4}$, 5 and 6 months.

The results of the germination tests on the seed stored in the boxes are given in Table 1. The seed stored in the kerosene oil tins was a complete failure, a fact which was obvious as soon as the tins were opened.

Table 1. *Germination of samples of stored tea seed.*

Sample no.	Storage period	Total no. of seeds	Number germinating	No. not germinating	% germination
1	1 month	8,122	7,293	829	89.8
2	3 months	7,459	7,336	123	98.5
3	$4\frac{1}{4}$ months	8,671	8,387	284	96.7
4	5 months	8,384	8,200	184	97.8
5	6 months	8,234	7,609	625	92.4

In the above experiment the figures apply to all the seed in each box. The seed in each sample was picked over at regular intervals, and in every case the good seed germinated within 5-6 weeks of the first picking over. The results speak for themselves. The only disappointing result was sample No. 1. This box was despatched to a friend of mine who was in need of seed. The seed was given on condition that careful germination results were kept. I think that this must have been left to the tender care of a nursery labourer! The other boxes were germinated most carefully under my personal supervision and can be vouched for.

Since it is commonly held that "floaters" are bad seed, I decided to germinate the sinkers and floaters in sample No. 5 separately. This box had been stored for 6 months. The results are given in Table 2.

Table 2. *Germination of "floaters" and "sinkers" in tea seed stored for 6 months.*

Date picked over	No. of seeds germinated		
	"Floaters"	"Sinkers"	Total
31-3-55	1,035	1,642	2,677
4-4-55	1,010	1,475	2,485
8-4-55	500	515	1,015
12-4-55	305	274	579
16-4-55	185	154	339
20-4-55	160	83	243
24-4-55	152	36	188
27-4-55	57	7	64
2-5-55	11	2	13
6 -5-55	6	0	6
Total germinated	3,421	4,188	7,609
„ ungerminated	604	21	625
Germination %	85	99.5	92.4

I hope that the germination results above will be of some comfort to those who believe that floaters are automatically bad seed and will not germinate. Seed when collected is always "floated" before sorting and it is only the floaters from the initial test which can be said to be bad and that is not always so.

I have received a few complaints from purchasers that 50 per cent. of the seed supplied are floaters. These have even been returned to me on occasions. They have germinated very well! As much as 5 days to a week may elapse between collecting and sorting seed until they arrive at their destination, during which time there may have been a certain amount of drying which will cause the seed to float. Immediately seeds are received they should be "floated". Sinkers should immediately be put out to germinate in moist sand and the floaters can be left in water for several hours during which time the majority will sink. Floaters may then, if desired, be germinated separately and will in all probability take somewhat longer to germinate. But do not condemn floaters automatically as useless and throw them away.

I have to thank the Managing Director of Cold Stores Ltd., for his co-operation in these experiments. Without his assistance the experiments could not have been carried out to, I consider, a very successful conclusion. For the information of anyone who may be interested the charge for storing seed at Cold Stores Ltd. would be Rs. 3/- per case of 40 lb. or part thereof, per month or part.

FERMENTATION IN RELATION TO HEAT DEVELOPED IN ROLLING

E. L. Keegel

Of all the external factors influencing the fermenting process in tea manufacture temperature is undoubtedly one of the most important because fermentation is an enzymic process. According to work carried out on the biochemistry of tea, in which the activity of the enzyme extracted from tea leaf was studied, it was found that under *in vitro* conditions the temperature for optimum enzyme activity was 81°F[1], and that above this temperature its rate diminished rapidly. It does not necessarily follow, however, that at this optimum temperature the characteristics of a tea liquor are at their optimum.

Even should an ideal temperature be determined, the batch process of rolling and subsequent operations of roll-breaking and extraction of dhool preclude any such Utopia being realised for the present. For it must be remembered that fermentation is not confined only to that period during which the leaf lies on a fermenting rack; fermentation commences from the time leaf is bruised in the rollers. Thus each dhool is not only subject to a different temperature, but to a variable temperature in the course of fermentation. To maintain a constant temperature throughout rolling, roll-breaking and the final stage of fermentation would indeed be a costly undertaking.

It would appear, therefore, that, under the existing system of tea manufacture, the determining of an ideal temperature in fermentation is not of much practical value. It would really be far more useful to know what temperature is harmful and the period for which its influence is most marked. With this knowledge the way should be clearer to an understanding of what changes take place in the warmer conditions induced by rolling.

The fact that most of the fermentation proceeds in the rollers at temperatures considerably higher than at room temperature makes this question all the more important. The vital part that the heat generated in rolling plays in fermentation is recognised, but there appears to be little information available on the extent to which this heat affects the individual characteristics of a tea liquor.

The term heat can be interpreted in many ways as it is only a sensation which is entirely relative to the conditions under which it is noted. For example, leaf leaving a roller at a temperature of 70°F in the early hours of a very cold morning may feel just as hot to the touch as, say, when it is at 90°F in a room temperature of 80°F. But the fermentation will be obviously significantly different in the two cases. Unless, therefore, there is a clearer insight into this question, which can only be obtained by actual temperature measurements, this so-called heat will continue to be a bugbear in tea manufacture. What is perhaps meant by the popular phrase 'Heat is the enemy of quality' is unnecessary heat, but even so the phrase is vague and perplexing.

As the scope of this article is to show the influence of high temperatures in fermentation, which generally prevail during the rolling process, no attempt is being made to set down any specific critical temperature below which fermentation is inhibited. But a word or two about low temperatures may not be out of place.

Tea leaf is known to ferment at exceptionally low temperatures, but the action is so slow that the period has to be unduly prolonged for the leaf to approach any semblance of the fermentation associated with that obtained at normal temperatures. The use of chilled rollers[2] has shown that fermentation proper takes place only after the leaf is exposed to the higher temperature in the rolling room. It has also been shown that in the range of 50°F to 68°F the best all round tea is obtained when fermented at the higher temperature[3]. Further evidence of slowing down in fermentation as a result of low temperatures is provided by the experimental rollers at St. Coombs each of which has a capacity of only 30 pounds of withered leaf. On account of their small charges the rise in temperature of leaf rolled in these machines is so small that a considerably longer period of fermentation than what is considered normal is found necessary. In spite of the extended period the liquors are sometimes inclined to be greenish.

From the foregoing observations it may be concluded that low temperatures are not very favourable to fermentation. How then can a satisfactory explanation be given for the success obtained in up-country factories at certain times of the year when the temperature of the atmosphere goes down to very low levels? The answer lies in the fact that the leaf itself during these periods possesses such marked quality and flavour that these two virtues, if present to a high degree, swamp the chief characteristic developed in fermentation, namely, colour. Nevertheless, a certain amount of fermentation does occur because of a noticeable rise in temperature of the leaf during rolling. This also helps to keep the leaf at a temperature higher than that of the rolling room for a considerable time after it has been sifted. Reference to the appendix to this article will convey an idea of the effect of rolling and roll-breaking on the temperature of leaf under different conditions. It will be evident from the figures given that, if not for the heat generated during rolling, very little fermentation will take place at low room temperatures.

Thus the tea roller, although regarded as a cumbersome part of factory equipment, is fulfilling a very useful purpose besides rupturing the cells of the leaf. In the slow process of extracting the juice from the leaf it provides the heat necessary for fermentation, but it can, however, not be used to the best advantage in the absence of knowledge of the actual effect of the temperatures normally reached by the leaf in the rolling process.

To assess accurately the effect of any particular temperature from the time the leaf is bruised and fermentation starts is, of course, extremely difficult, because rolled leaf in the first place is not subject to a fixed temperature during the period of rolling and, secondly, the rise in temperature of the leaf is dependent on the pressure applied and the degree of circulation. Other factors from day to day which can affect the rate of fermentation are the type of leaf, the period and degree of wither, roller charge, and the rolling room temperature. The most that can be done, therefore, is to find out how the characteristics of a tea liquor are altered at some pre-determined temperature in the course of fermentation after leaf is discharged from a roller.

In these studies the material worked with was the second dhool, which was chosen for three reasons:—

(1) It is much more uniform than the first dhool, which generally contains a higher proportion of tip and flaky leaf.

(2) It has not been subject to too high a temperature for too long a period.

(3) The influence of a high temperature of this dhool would give a reliable estimate of the effect of the heat generated in later rolls.

Since any approach to a study of the influence of temperature in fermentation must take period into consideration, it should be borne in mind that the material used for these experiments would already have been fermented for a period of an hour during rolling at a temperature higher than room temperature and for half an hour at room temperature during the roll-breaking intervals. It is a factor not to be overlooked, as will be seen from the results obtained from leaf rolled in a commercial roller in comparison with the effect produced on leaf from an experimental roller. In the former case temperatures as high as 90°F were recorded, whereas leaf rolled on an experimental scale never attained a temperature higher than 80°F. Table 1 gives the mean temperatures observed.

Table 1. *Room temperatures and temperatures of the leaf at end of rolling and after roll-breaking.*

	Room temperature	TEMPERATURE OF LEAF	
		At end of rolling*	After roll-breaking
During flavoury season			
(*a*) Commercially rolled leaf	60°F	83°F	68°F
(*b*) Experimentally rolled leaf	60°F	70°F	65 F
During off-quality season			
(*a*) Commercially rolled leaf	68°F	88°F	76°F
(*b*) Experimentally rolled leaf	68°F	76°F	72°F

*Two 30 minute rolls, the first dhool being 15% and second 20% through a No. 5 roll-breaker mesh.

The significant point to note from these figures is that the temperature of the leaf after roll-breaking did not fall to room temperature. In the case of (*a*) it was approximately 8° higher and in the case of (*b*) 4° higher. These temperatures showed practically no change during the whole of the period the leaf was fermented on the racks in the atmosphere of the rolling room.

It is not necessary to go into the details of the technique employed for comparing the leaf fermented at room temperatures with leaf fermented at higher temperatures. Suffice it to say that all precautions were taken to minimize the effect of outside factors and to ensure as far as possible that the result obtained was primarily due to the effect of the particular temperature under investigation and that temperature alone. However, it is advisable to accept the results with some reserve until they are confirmed by the use of apparatus more suitable than that used for these studies.

The following points require to be noted:—

(1) As previously stated, period must be considered in conjunction with temperature for judging the effect of the latter. The standard chosen for these experiments was leaf fermented at normal room temperatures. It was necessary, therefore, in the first instance, to determine the optimum period at ordinary temperatures.

(2) Higher temperatures were compared with the standard for the same length of fermentation as the optimum period at normal temperatures.

(3) The effect of a shorter period at the higher temperature was also studied.

(4) The temperatures hereafter referred to are those of the leaf, unless otherwise stated.

(5) Any period mentioned is the actual time during which the leaf had been subject to the temperature under discussion. It does not include the periods of rolling and roll-breaking over which operations the time taken was $1\frac{1}{2}$ hours.

RESULTS

Optimum period at Room Temperature:—(*a*) During flavoury season:—
(Temperature of leaf about 68°F)
(Room temperature about 60°F)

(1) When flavour was present the optimum period was found to be 1 hour. A shorter period resulted in liquors that were too green and raw.

(2) Flavour definitely declined after 1 hour. Quality also had a downward trend, but not to the same extent.

(3) The most valuable tea was 1 hour, when compared with 2 and 3 hours, despite the least amount of colour.

(*b*) Off quality season:—(Temperature of leaf about 76°F)
(Room temperature about 68°F)

(1) There was very little to choose between 1, 2 and 3 hour periods. The better quality as a result of a shorter period compensated for the poorer colour.

(2) The preference for any particular period was entirely governed by the market requirements existing at the time the teas were tasted.

(3) Colour and quality are so closely related that both features have to be taken into consideration.

(4) On the whole, 2 hours gave the best all-round tea. 1 hour was thinner and 3 hours had slightly less quality.

Effect of Higher Temperatures:—(*a*) 80-85°F:—For a period of 2 hours quality was slightly worse than normal. The slight gain in colour did not compensate for the slight loss in quality. During a very low quality season colour, it must be noted, increases in importance in proportion to the drop in quality.

On shortening the period to 1 hour, however, quality improved and was about the same as that for the best tea at normal temperatures.

Strength and infusion were not affected by the higher temperature.

During the flavoury season, the effect of the higher temperature was more strongly marked. Compared with the normal for a period of 1 hour (the optimum for room temperature) the higher temperature for a similar period resulted in appreciably worse flavour, slightly worse quality and appreciably better colour. The normal though possessing much less colour was the more valuable tea.

(*b*) 85-90°F:—Results were very similar to those obtained at 80-85°F.

(*c*) 90-95°F:—The effect of this higher range of temperatures was clearly significant. Compared with the normal for the same period of 2 hours, quality was appreciably worse and despite improved colour the liquor was described as not quite true. A slight dullness in the infusion was also noted. Strength of the liquor, as in the lower range of temperatures, was unaltered.

The shortening of the period to 1 hour resulted in a distinctly improved tea. Yet, the normal was slightly preferred as it had more point and a little more character. The difference in quality was, however, so small that the extra colour in the tea fermented at the higher temperature might have made it more valuable in certain markets. The shorter period also improved the infusion but it was slightly greenish and not as bright as the normal.

The effect on flavour and quality, when these two features were present at a high level, was to make the former characteristic inferior and the latter appreciably worse. They were not counter-balanced by the appreciably better colour and the tea as a whole was considered inferior.

(*d*) 95-105°F:—These high temperatures have actually been recorded in commercial rollers, usually in later rolls in low-country factories and sometimes even in factories at higher elevations when leaf is rolled under very heavy pressure.

Their effect for 2 hours was to produce a tea definitely worse than at normal temperature for the same period. The liquor was described as having a peculiar metallic character and was plain and unattractive with a dull infusion.

There are two remarkable influences of these very high temperatures worth mentioning. Colour of the liquor had not improved to the same extent as that in the range 80-95°F, and strength that had shown no change was slightly reduced.

A shorter fermentation of 1 hour gave results very similar to those obtained at 90 to 95°F, but the liquor was a little green.

A still shorter period of 30 minutes was tried out but the liquor was not quite true though it possessed the same amount of quality as a tea fermented at normal temperatures for a period of about 2 hours.

Flavour, of course, declined rapidly with the lengthening of the period and at 3 hours was absent.

High Temperatures followed by periods of Fermentation at Normal Temperatures:—This aspect of the influence of high temperatures was specially investigated in order that some information might be obtained on the changes that took place after a 30 minute period of heavy rolling. The same material as that used for the foregoing experiments, namely, dhool 2, was taken, and subjected for half an hour to temperatures of 90 to 100°F. The leaf was then fermented for periods varying from $\frac{1}{2}$ to $1\frac{1}{2}$ hours at room temperature.

The extension of the fermentation resulted only in a slight increase in colour with a proportionate loss in quality. The character of the liquor was barely changed and, compared with the standard fermented for 2 hours at room temperature, all these teas were not so 'round' in liquor.

Other effects of High Temperatue:—(1) It is not quite clear whether 'greeness' of liquor is reduced by a higher temperature. When intrisically present this feature may be accentuated under the influence of very high temperatures for long periods. At the same time, bright, rosy liquors have been obtained at a temperature of 90°F. The evidence was inconclusive.

(2) Creaming in some instances was better at higher temperatures.

(3) It would also appear that slightly blacker teas result from higher temperatures.

Effect of High Temperatures on Leaf from Experimental Rollers:—The foregoing results refer to commercially rolled leaf and it will be of interest to see how these same temperatures have affected leaf rolled under cooler conditions. The experimental rollers at St. Coombs provided the necessary material. Working with 2nd. dhool again, which incidentally was rolled at a temperature approximately 10° less, the following results were obtained:—

80-90°F:—Compared with the standard fermented for 3 hours, the normal period which the experimental 2nd. dhool receives, the higher temperatures for a shorter period of 1½ hours produced a distinctly better tea. It was more fully fermented than the standard, which was inclined to be thin. Flavour also was more prominent in the tea fermented at the higher temperature. For a longer period than 1½ hours quality and flavour were not so pronounced in the high temperature teas.

95-105°F:—Flavour and quality were hardly affected for very short periods, but on account of the thin, hard liquors produced, the teas were substantially worse in value than the normal.

It was noted again that colour did not improve to the same extent as at 80-90°F. Even for a period of 1½ hours colour was slightly worse than the standard fermented for 3 hours. Though the liquors compared favourably with the standard as regards individual characteristics, they lacked the 'smoothness' of the liquors from the normal temperature fermentation and were, therefore, valued lower.

SUMMARY OF RESULTS

In order to get a clearer understanding of these results a summary is given of the influence of temperature on each of the main characteristics. It must be repeated that temperature refers to that of the leaf.

Quality:—(1) High temperatures up to about 90°F are not detrimental to quality, provided periods are suitably adjusted. A total over-all period of more than 1½ hours at this temperature brings about liquors that are not quite true, accompanied by a significant loss in quality.

(2) Temperatures over 95°F even for a short period of half an hour are harmful.

(3) For equal periods, no matter of what length, a lower temperature produces better quality.

(4) At normal temperatures quality takes some time (approximately an hour on the racks) to reach its optimum level, after which it gradually declines. In the case of high temperatures no such optimum was noted. The level of quality was inversely proportional to the period.

Colour:—(1) A very close relationship exists between colour and quality.

(2) High temperatures improve this character considerably.

(3) But if the temperature is in the region of 95°F development of colour is not so rapid.

(4) There is not a very significant difference in fermentation at temperatures between 70°F and 80°F.

(5) Below 70°F fermentation is slow.

(6) It is most active between 80°F and 90°F.

Strength:—(1) At normal temperatures period has no effect.

(2) There are indications that it is not affected appreciably by higher temperatures as well.

(3) Strength is affected only if the period is unduly lengthened to many hours.

Flavour:—(1) The influence of high temperatures on flavour is very similar to that on quality up to a period of about $1\frac{1}{2}$ hours, after which it is affected to a much greater extent.

(2) It can be lost if leaf is exposed to a high temperature for a long period.

(3) Its rate of development depends on the temperature of leaf in the rollers.

(4) If high, that is over 80°F, a further period of fermentation, however short, at this temperature adversely affects it.

(5) If the temperature of leaf in the rollers is considerably below 80°F, a higher temperature subsequently is not unfavourable.

(6) A temperature of over 90°F, however, is harmful at any stage.

Infused Leaf:—(1) Below 90°F temperature influence was small.

(2) Lower temperatures as a rule gave slightly brighter infusions.

(3) Above 95°F infusion is liable to be dulled and becomes greener.

TENTATIVE CONCLUSIONS

Though some of these results remain to be proved by the use of better controlled equipment the points of significant importance which emerge are:—

(*a*) High temperatures are harmful only if uncontrolled.

(*b*) For preservation of quality and flavour temperatures of over 90°F must be avoided.

(*c*) The shortest possible fermentation is advisable when flavour is present.

(*d*) The period of fermentation on the racks depends on the temperature the leaf has been exposed to in the rollers, the higher the temperature the shorter the period.

(*e*) If the temperature is too high, *i.e.* above 95°F, even a short period of half an hour or less results in no improvement.

(*f*) Quality and colour are very closely related in the temperature range of 70 to 90°F. At higher temperatures there is no relationship.

(*g*) At about 70°F and below, fermentation is so slow that the period has to be appreciably lengthened to obtain colour. Quality is not unduly sacrificed in achieving this objective, but a decline in flavour occurs.

(*h*) Strength is not appreciably affected by temperature or period.

(*i*) Though high temperatures may reduce greeness, there are indications that when this character is intrinsically present in the leaf it is accentuated by high temperatures of over 90°F for periods of half an hour or more.

(*j*) Creaming, usually associated with strength, does not appear to be affected by temperature. But at about 100°F and over there seems to be a slight loss, indicating the formation of a higher proportion of insoluble products. The darkening of the infused leaf strongly suggests this.

(*k*) Temperatures of over 95°F are inadvisable even for a short duration during rolling.

(*l*) Temperatures of 80 to 90°F are not harmful to quality provided the overall period does not exceed 2 hours.

(*m*) During the flavoury season, temperatures of 80 to 90°F are permissible, but the period must be as short as possible. Lower temperatures are, however, preferable.

(*n*) During the off-quality season high temperatures in rolling are advantageous, but a temperature higher than 90°F cannot be recommended.

Although it is realized that the experimental work on the influence of high temperatures has been carried out under conditions that vary greatly from those actually encountered in practice, the knowledge acquired throws some light on the influence of heat developed in the rolling process. The details given in the appendix should assist in making the picture clearer.

ACKNOWLEDGMENTS

I wish to express my thanks to Mr. J. Lamb, for initiating these experiments, to Mr. S. M. Gunaratnam, who assisted in carrying them out, and to the Tea Tasters in Colombo for their ready help in the tasting of the numerous samples.

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APPENDIX

Table 1. *Heat developed in rollers under different conditions*

Situation of factory	Type of rolling	No. of roll	Pressure application	Period of rolling	Dhool outturn %	Rolling room temperature °F	Temperature of leaf at end of rolling period °F	Rise in temperature °F
Low-country	Light	1	Nil	25 mins.	7	79	90	11
		2	5 on 5 off	,,	18	79	94	15
		3	,, ,,	,,	19	81	95	14
,,	,,	5	,, ,,	30 mins.	—	78	90	12
		6	,, ,,	,,	—	80	95	15
,,	,,	5	Continuous	20 mins.	—	86	98	12
Mid-country	Very light	1	5 on 5 off	30 mins.	2	71	82	11
		2	,, ,,	,,	5	71	83	12
		3	,, ,,	,,	16	72	84	12
		4	,, ,,	,,	15	73	86	13
		5	,, ,,	,,	14 (48% B.B.)	73	83	10
,,	,,	1	Nil	40 mins.	—	72	80	8
		2	,,	30 mins.	—	72	78	6
,,	Somewhat heavy	1	5 on 5 off	40 mins.	—	72	87	15
		2	,, ,,	30 mins.	—	72	84	12
Up-country	Heavy	1	5 on 5 off	30 mins.	15	65	85	20
		2	,, ,,	,,	21	65	88	23
		3	,, ,,	,,	20	65	89	24

Up-country	Light	1 2 3 4 5	5 on 5 off „ „ „ „ „ „ „ „	30 mins. „ „ „ „	8 9 16 15 16 (36% B.B.)	71 70 70 70 70	80 81 83 84 84	9 11 13 14 14
„	„	1	Continuous	45 mins.	5	65	82	17
„	Very heavy	3 4	5 on 5 off „ „	25 mins. „	23 33 (11% B.B.)	68 68	92 98	24 30
„	Heavy	1	8 on 2 off	30 mins.	—	53	70	17
„	„	2	3 on 2 off	35 mins.	—	49	77	28
„	More dhool in early rolls	1 2 3 4 5	8 on 2 off 4 on 1 off „ „ „ „ 3 on 2 off	30 mins. „ „ „ 25 mins.	26 23 20 17 9 (5% B.B.)	66 66 66 66 66	83 83 85 84 82	17 17 19 18 16
„	Harder rolling in early rolls	1 2 3 4	8 on 2 off 4 on 1 off „ „ „ „	30 mins. „ „ „	35 26 17 16 (6% B.B.)	67 67 68 68	81 82 84 82	14 15 16 14

NOTE:—Roll-breaker mesh—Low country No. 4 or thereabouts.
Mid-country No. 5 „
Up-country No. 6 „

Table 2. *Effect of degree of wither on temperature rise.* (*Low-country factory*).

Rolls	Rolling room temperature	Temperature of leaf at end of rolling period		Rise in temperature	
		Hard wither	Soft wither	Hard wither	Soft wither
1st.	81°F	89°F	89°F	8°F	8°F
2nd.	81°F	96°F	90°F	15°F	9°F
3rd.	77°F	97°F	91°F	20°F	14°F

Table 3. *Comparison between two methods of pressure application in relation to rise of temperature of leaf* (*Up-country factory*).

(*a*) 2nd. rolls—40 minutes—25% dhool		
	5 mins. on, 5 mins. off	15 mins. on, 5 mins. off
Rolling room temperature	63°F	65°F
Temperature of leaf fed into roller	74°F	74°F
Temperature of leaf after 15 minutes of rolling	81°F	82°F
At end of rolling (40 mins.)	84°F	86°F
Final rise in temperature	21°F	21°F
(*b*) 3rd. rolls—20 minutes—15% dhool		
	5 mins. on, 5 mins. off	15 mins. on, 5 mins. off
Rolling room temperature	66°F	68°F
Temperature of leaf fed into roller	76°F	77°F
Temperature of leaf at end of rolling	82°F	86°F
Final rise in temperature	16°F	18°F

NOTE:—Pressures adjusted to give the same dhool outturns.

Table 4. *Effect of three methods of rolling on rise of temperature of leaf.* (*Up-country factory*).

Method of rolling	No. of roll	Dhool outturn %	Rolling room temperature °F	Temperature of leaf at end of rolling period °F	Rise in temperature °F
(*a*) Epicyclic -pressure (no pressure cap)	1	20	67	90	23
	2	32	67	91	24
	3	38 (10% B.B.)	68	91	23
(*b*) Battens, pressure cap (5 on, 5 off)	1	13	67	92	25
	2	16	67	90	23
	3	25	68	92	24
	4	35 (11% B.B.)	69	98	29
(*c*) Battens, pressure cap (Continuous pressure)	1	13	66	91	25
	2	16	66	90	24
	3	25	66	95	29
	4	35 (11% B.B.)	67	100	33

NOTE:—Each roll of 25 minutes duration, and pressures adjusted in (*b*) and (*c*) to give equal dhool outturns.

Table 5. *Effect of roll-breaking on temperature of leaf.* (*A few observations*).

Rolling room temperature °F	Temperature of leaf at end of rolling °F	Temperature of leaf after roll-breaking °F	Cooling effect °F
46	75	63	12
46	77	58	19
61	88	68	20
62	83	70	13
63	87	71	16
67	93	75	18
69	88	76	12
69	90	74	16
70	92	76	16

NOTES ON A HAILSTORM

J. E. Davidson

(Nayabedde Estate, Bandarawela)

In various parts of the tea-growing districts of Pakistan, India and East Africa violent hailstorms are known to be a common feature of those countries. But in Ceylon they are not so common. On the 1st July, 1954, however, a hailstorm of unprecedented severity occurred on Nayabedde Estate shortly after midday and lasted for about three quarters of an hour.

To give some idea of the intensity of the storm, although the Superintendent's lawn was white with hailstones, which more nearly resembled snow on the ground, the tea and tree legumes were unaffected to any extent; but on the following morning when a survey of the centre of the affected areas was carried out the damage observed was staggering.

The area affected was some 230 acres, of which 123 acres, which appeared to be in the central path of the storm, were badly defoliated.

The actual type of damage to the tea varied according to the age from pruning as follows:—

(1) Tea 10 months from pruning in which the secondary growth carried only thin red wood at the base.

(2) Tea 2 years or more from pruning.

(3) Pruned tea.

In (1) the foliage had almost completely disappeared exposing the primary wood, the bark of which was badly lacerated on the upper surface or on the side facing the path of the storm.

In (2) defoliation was apparent to a greater or lesser degree and the shoots presented a "claw-like" appearance, the normal flush having disappeared. Here, too, much bark damage had been suffered by the primary and secondary wood.

Fortunately, the pruned area, (3) above, was only a small acreage, for where prunings did not happen to afford protection the bark was stripped off numerous bushes.

After the storm, drought again set in and the first visible effect on such top foliage as existed was sunscorch.

Some remedial action was obviously called for and it was decided in consultation with the Plant Physiologist and Mycologist of the Tea Research Institute to take the following action:—

Tea referred to in (1) above would be broken back and that affected as in (2) should be cut across below any defoliation or bruising in order, in both cases, to avoid terminal die-back and in addition in the latter case in the hope that maintenance foliage would be re-established. This hope was justified.

It was also decided that the whole of the 123 acres should be sprayed with "Limbux" lime at the rate of 1½ cwts. per acre, with an admixture of copper sulphate at 5 lbs. per acre. The object of this was to provide some sort of protection from infection to branch wounds, and to assist in callusing.

Loss of crop was considerable and though there was a compensating minor "rush" after the cut-across area recovered, the computed loss was in excess of 20 lbs. made tea per acre. Figures calculated later suggest that the total loss over the whole of the affected area was in the region of 20,000 lbs. of made tea.

One acre was left as a control. No lime was applied and periodic breaking back only was carried out. Shade trees were left in their damaged state, but elsewhere were pollarded.

At the time of writing, 9 months after the storm, one is able to judge just how effective were the steps taken to prevent die-back and/or the admission of branch canker.

Recovery of the tea 10 months and 2 years from pruning has been highly satisfactory and the maintenance foliage has completely re-established itself. There is also excellent callusing over the wounds in both of these areas, but in the pruned area die-back was fairly considerable and a "sanitary prune" has been necessary.

In the one acre control plot, individual bushes have grown fresh maintenance foliage, but the general tendency has been for a canopy of foliage to form towards the top of the bushes with many pockets where no new growth has occurred on account of terminal die-back. The correctness of the action in cutting across the damaged areas would, therefore seem to have been justified.

Finally, it has been noticed that the tree legumes pollarded after the storm are recovering, while the untended shade trees have made little fresh growth.

Mr. B. N. Webster comments:

The course of action suggested to Mr. Davidson, although not in accordance with standard practice elsewhere, appears from the results given below to have been quite efficacious. In North India it is customary to rest the bushes following hail damage, with an overall application of 1 lb. of 50 per cent. copper fungicide in 40 gallons water, but it was felt that, as branch and bark damage was considerable, a soaking spray of limewash should be given. The copper sulphate was included for its fungicidal nature, the whole resulting in an "excess lime Bordeaux mixture". Further, the cut across prune was advised to re-establish a plucking table with a minimum of delay, and also to remove all damaged and probably already infected material.

Results.—From May to August, 1955, random samples of branches of similar thickness were removed from each of four areas, on the 15th of each month. Ten branches, 12 inches in length, from each sample were examined for healed and open lesions. A lesion was considered to be healed, when completely callused over, and open when the wood was still exposed, and fungus activity still apparent. The majority of lesions appeared to carry fungi of the *Macrophoma* type; *Nectina* spp. common in India on hail damaged shoots, were found only once.

Table 1.—*Percentage of healed and open lesions in treated and untreated areas.*

Date of exam.	17/31				23a/44			
	Treated		Untreated		Treated		Untreated	
	Healed	Open	Healed	Open	Healed	Open	Healed	Open
May	50%	50%	20%	80%	66%	34%	—	—
June	78%	22%	54%	46%	74%	26%	55%	45%
July	73%	27%	33%	67%	86%	14%	55%	45%
August	82%	18%	35%	65%	84%	16%	44%	53%

It will be readily seen from Table 1 that a consistently higher percentage of healing has been found in the treated areas. For future reference, in the event of severe hail damage being experienced, we would recommend the above treatment of cutting across followed by lime-washing, incorporating a copper fungicide in place of the copper sulphate which is not always readily available.

MISCELLANEOUS NOTES

UPROOTING TEA

W. J. Childerstone

(Balangoda Group, Bogawantalawa)

Mr. Childerstone, the Manager of Balangoda Group, has kindly sent us the following notes on the uprooting of tea on his estate with a Hesford Hercules winch and Ferguson tractor. We believe his costs will be of general interest, since they are considerably lower than those for St. Coombs, which were quoted at the recent Conference and published in the last issue of the Tea Quarterly. In comparing the two sets of figures, however, it must be remembered that the costs on St. Coombs were based on uprooting 5,000 *bushes per acre of poor jat tea, on steep slopes, where considerable digging out is necessary before the cable can be effectively fastened round the bush.*

Uprooting of tea with a Hesford Hercules winch and Ferguson tractor has been in progress on Balangoda Group since April, and the following summary of costs during April and May may be of interest:—

Cost of uprooting tea bushes—Balangoda Group

Item		*Cost, Rs.*	*Cost per bush, Cts.*
Driver's pay	...	199.86	0.852
Petrol	...	22.86	0.097
Kerosene oil	...	192.60	0.821
Oils	...	67.28	0.287
Repairs, etc.	...	4.85	0.020
Labourers on contract @ Rs. 150 per acre		1,125.00	4.796
Total	...	1,612.45	6.873

No. of tea bushes uprooted	23,460
No. of bushes uprooted per day	450
Total acreage uprooted	7 acres
Speed of work	1 acre per week
Cost per acre	Rs. 215

The item "labourers on contract" is for manipulating the main cable, and fixing the steel cable collars around the tea bushes on to which the main cable is hooked. It is important to have ample spare collars to avoid delay in the work; sixteen have been in use here. A gang of seven Tamil labourers were very pleased to carry out this work at Rs. 150/- per acre.

Depreciation of winch and tractor has not been shown, but, assuming a 300 week working life and an initial capital outlay of Rs. 15,000 for this equipment, depreciation would work out at Rs. 50/- per week, that is Rs. 50/- per acre, making an overall cost of Rs. 265/- per acre. Manual uprooting in the same area cost Rs. 320/- per acre, and the work is not nearly so clean.

I am now fully satisfied that using this winch is the most satisfactory method of uprooting tea. The roots are extracted cleanly with very little breakage, and, unless there is a history of root disease such as *Poria*, I do not consider it necessary to subsequently fork over the ground.

To sum up, I consider that the average Ceylon tea at 3,300 bushes to the acre can be effectively uprooted by the Hesford Hercules winch, operated by a Ferguson tractor, at not more than Rs. 300/- per acre, including depreciation, and that 1 acre per week can be completed, provided the operation is done on contract.

SOIL SAMPLING FOR pH AND EELWORM TESTS

J. A. H. Tolhurst

The limited facilities of the Tea Research Institute only permit us to do two types of advisory soil analysis, viz: the pH test, or estimate of acidity, and the population count of parasitic eelworm species. As the demand for this service is high and as the request for instructions on taking samples comes in quite frequently a joint memorandum from the Chemistry and Nematology departments may be of value, as the requirements of each are the same.

Soil Variation.—At first sight the taking of a sample might seem to be one of the simplest of operations, and this could be true if it were not for the inherent variability of the soil. Soil is a most complex biological system and over a small area some of the factors can change enormously.

In a recent very detailed survey of several small plots on St. Coombs the pH showed a range from 3.7 to 5.6 over three hundred yards. This, by interpretation of the mathamatical device known as the "pH scale", means that the soil at pH 3.7 was nearly one hundred times as acid as that at 5.6. Small variations were found over distances of a few yards, and this on an apparently uniform slope of tea.

Our analyses can only refer to the actual soil which we receive and we can not guarantee that our findings will hold good for the neighbouring soil. Our determinations are as accurate as modern equipment can make them, but they are only as true as the method of sampling will allow them to be.

Sampling a Field.—If a general picture of pH and eelworm is required it is best to consider the field as several units according to the lie of the land. A forty acre field running up hill and down dale is not an entity. From each unit, which should not be larger than 3 to 5 acres, about twenty equal samples should be cut, mixed together, and a sub-sample sent for analysis.

If a poor area is to be examined then the number of samples from within the area need not be so great. It is not always appreciated that the good area immediately adjacent must be sampled as well for comparison.

Sampling New Clearings.—The same principles apply, except that it is better to send more separate samples for analysis, with their positions in the field marked. In this way a trend to alkalinity or high eelworm could be spotted which might be masked if several samples were bulked together. These two sources of trouble often occur in small pockets, later spreading in the case of eelworm, and if the Tea Research Institute does not get samples from such areas it can not be held responsible in later years for a knoll which persists in being a conspicuous bare patch.

Sampling for a Nursery Site.—This requires the most detailed sampling of all, as the soil is often added to by importation of compost, jungle soil, and even wood ash. Consequently the variation from one bed or basket to the next may be very great.

It can not be stressed too strongly that all the components of a proposed nursery site should be sent for analysis BEFORE planting. Too frequently do we get young plants in the last stages of their struggles with eelworm, or too high pH, and it gives no pleasure to us or consolation to the planter to know that nothing can be done.

In a nursery bed the question of depth of sampling is extremely important, as the beds are often built in layers of different composition, and this will be considered next.

Technique of Sampling.—It is usually worth while to sample the 0-6″ layer and the 6-12″ layer separately. It has been known for a top soil to be derived from limestone fragments washed down from a hill top, while the sub-soil was of a normal acidity, being derived from the rock actually underneath it.

In nursery beds sampling these two layers may be said to be essential.

An alavangoe will penetrate to 12″, if the soil is that deep, without much difficulty. This is important as the tendency with a mamottie is to scrape a lot of soil from a shallow depth to save effort. Some samples have been sent which looked suspiciously like the nearest loose earth from a bank or out of a drain.

The ideal place for sampling is around feeding roots of the plant, as parasitic eelworms will only be found in and around acceptable food. Sampling too close to the stem may result in samples which though negative for parasitic eelworms, have in fact come from areas of high infestation.

Packing and Posting.—It may seem unnecessarily particular to give instructions on this point, but in some ways it is the most vital of all, and from our observations, it is obvious that some times there is little appreciation of what can happen in the post.

The first essential is that the soil should reach us. Screws of newspaper, and sadly dilapidated tins, with or without a makeshift lid, invariably arrive almost empty.

The soil should also be moist, by which we mean as moist as it was in the field when sampled. The pH may alter if the soil is allowed to dry, even for a few days in transit, but even more serious is that an eelworm count is not possible after a soil has dried out.

To meet these requirements there is one almost ideal and universal container. The cigarette tin, providing it is in reasonable condition with a good lid, gives us sufficient soil, keeps it moist and travels very well. Some adhesive paper or string round the tin and good brown paper are perfectly adequate and there is no need to have boxes made unless many tins are to be sent.

One final point, which can cause extra work or even confusion at our end, is the labelling. Two tins marked A and B may seem perfectly distinct when they leave the estate, but at the Tea Research Institute they may be in company with twenty or more similar tins with a fair sprinkling of A's and B's. A fairly detailed label inside and outside the tin speeds our work and makes confusion less likely when they are being moved between the two departments.

We make no apology for this detailed note, because we feel planters would prefer to know that they are able to get the greatest information by adoption of a methodical sampling system. Further, although the majority of samples do arrive well packed and labelled, too high a proportion are quite useless. The more detail we receive with the actual sample the more likely we are to be able to give useful advice in return.

Soil sampling is one of those things which is not as simple as it seems, and is also an example of one which, if it is to be done at all, is worth doing properly.

REVIEW

"Crop Protection" by G. J. Rose, B.Sc., Entomologist, Micron Sprayers Ltd.,—London, Leonard Hill Ltd., 30/- net.

"Books cannot always please, however good," wrote Crabbe, but it is to be hoped that Mr. Rose's volume will find those whom it will please. It is possible that it may please those for whom it was written—"for the cultivator—faced with the problem of protecting his crops."—says the dust jacket, but few cultivators even to-day, have the time to spare, or, one finds in practice, the inclination, to read much of the technicalities of a very specialised subject which is thrust upon them willy-nilly. That it is not intended for those engaged in the academic study of crop protection is obvious, for the opening paragraph of the introduction reads like a commentary beginning one of the earlier documentary films, and contains one of the two attempts at humour to be found in the book. Had the humour been more in evidence, or entirely lacking, one might have felt that the author had made up his mind on the style to be adopted, but throughout, the impression is given that both style and contents fall between two stools.

With the exception of Chapter 1, which dismisses "Cultural Control" in a page and a half, perhaps to be expected in view of the author's commercial background, the chapters are well set out in three main sections on "Formulations", "Chemicals" and "Application Machinery". The chapters follow a quite logical sequence.

It is in Section 3, "Application Machinery" that one really feels that the author is on his own ground, and not relying on outside sources for his information, a particularly dangerous practice when those sources are not altogether reliable. Almost all available crop protection machinery is described, and very adequately illustrated, the merits of each being discussed as fully as possible. This section of the book, could, with advantage have been trebled in size and published under the title "Crop Protection Machinery," a publication which would prove most acceptable to those concerned with advising on crop protection.

Of the few references to tea it is perhaps unfortunate that two should be most misleading. On page 61 the author refers to T.C.A. as being " . . . . . successfully used to control grass type weeds in . . . . . tea". Those of us who have seen the phytotoxic effects of T.C.A. on tea, following application by enthusiastic amateurs, will view such a statement with concern! Likewise the recommendations for blister blight control may horrify those used to low-volume spraying. On page 100, in the chapter on Fungicides, blister blight is said to be controlled on mature tea by 10 lbs. per acre of 2 per cent. copper oxychloride dust every 7 days, and on tea recovering from pruning by 10 lbs. per acre of 6 per cent. dust every 4 days! This recommendation is repeated in the Appendix, "Summary of Control Measures", on page 207, with the slight alteration of 4 per cent. dust being substituted for 2 per cent. on tea in plucking, no mention whatsoever being made of wet spraying.

The book is excellently produced and contains a wealth of good photographic illustrations and line drawings, and had it been produced rather less hurriedly, and with more verification of details, it would quite probably have found a place on every planter's bookshelf.

B. N. W.

A GUIDE TO THE MANURING OF CEYLON TEA (1955)

J. Lamb, G. B. Portsmouth and J. A. H. Tolhurst

Publication of this guide earlier in the year, in leaflet form as T.R.I. Phamphlet No. 1, *met with such widespread approval that the desirability of reprinting it in somewhat more permanent form was clearly indicated. With the exception of the original preface, it is accordingly reprinted in full in this issue of the Tea Quarterly.*

Opportunity is, however, again taken to emphasise that the information given is essentially dated 1955, *and that it is based upon a combination of results obtained in the field and the laboratory during the past twenty five years. In the light of further experiments our recommendations may change and, as soon as there is substantial justification, new recommendations will be published.*

1. TEA IN BEARING

Recommended Mixtures

T.R.I. 500 Mixture

Sulphate of ammonia	...	320 parts
Saphosphosphate	...	105 „
50% Muriate of potash	...	75 „
		500 „

Or

T.R.I. 488 Mixture

Sulphate of ammonia	...	320 parts
Saphosphosphate	...	105 „
60% Muriate of potash	...	63 „
		488 „

From the point of view of plant nutrients there is no essential difference between these two mixtures. The difference is entirely a matter of availability and cost of 50% and 60% muriate of potash. The difference is so small that application rates are not practically affected.

Rate of Application

Annual crop lbs.	Minimum pounds of mixture required annually	Minimum rate of application per annum		
		N	P_2O_5	K_2O
400	275	36	17	21
450	300	40	19	23
500	325	43	20	24
550	350	46	22	26
600	400	53	25	30
650	425	56	26	32
700	450	59	28	34
750	475	63	29	36
800	500	66	31	38
850	525	69	33	39
900	550	73	34	41
950	575	76	36	43
1,000	600	79	37	45
1,050	650	86	40	49
1,100	675	89	42	51
1,150	700	92	43	53
1,200	725	96	45	54
1,250	750	99	46	56
1,300	775	102	48	58
1,350	800	105	50	60
1,400	825	109	51	62
1,450	875	115	54	66
1,500	900	118	56	68
1,550	925	122	57	69
1,600	950	125	59	71
1,650	975	129	60	73
1,700	1,000	132	62	75

Any estate obtaining crop levels above the maximum given in the table should communicate with the Institute for special advice.

Stress is laid upon the fact that the quantities given in the table are minimal and that where there is a demand for nutrients by heavy stands of shade trees, green manures, etc. some allowance must be made.

Many estates increase the basic figures given in the above table by 25%, and we are aware of instances where 50% increases have been made in very wet districts where the stand of shade trees and green manures is also very heavy. It is unfortunately impossible to give a rule of thumb recommendation for such allowances and this is a case where practical experience and judgment are indispensable. Every estate with proper records can judge the response to manures from the relation between the quantity of manure applied, the yield, and the consideration of the plant population. It is, however, pointed out that plants are not "penny in the slot machines" and that hasty judgment of response is to be deprecated. We also stress the fact that by "yield" we mean yield obtained by a high standard of plucking, reminding all growers that uptake of nutrients is dependent upon the bushes carrying adequate maintenance foliage. Manuring cannot compensate for over-plucking.

Some indication of the extent to which nutrients may be taken up by a newly planted stand of shade trees is given by the following specific instance in which 3 year old *Albizzia sumatrana* trees were found to have grown with such undue rapidity as to cause serious competition with the tea bushes. Analysis of the wood and roots of these trees made it possible to make the following estimate of the amounts of major nutrients taken up per acre by the shade trees in the three years since planting:—

Nutrient	(a) In timber lbs.	(b) In roots lbs.	(c) Total uptake lbs.
Nitrogen	30	53	83
Phosphoric acid	1	8	9
Potash	78	96	174

The figures in column (*a*) represent a permanent loss of nutrients, since these would be taken away in the timber. The figures in column (*b*) represent temporarily immobilised nutrients, since they will be slowly returned to the soil when the shade trees are felled and the roots decay. However, the total additional demand for available nutrients per acre in the first three years is the sum of both these amounts which is shown in coloumn (*c*).

An arbitrary increase of 25% in the recommended application rates to allow for uptake of nutrients by shade trees is not, therefore, unreasonable. There can be clearly no substitute for skilled "on the spot" interpretation of the basic recommendations given in this publication.

Frequency of Application

For low yielding areas, that is to say yields below 700 lbs. per acre, the quantity to be applied limits the frequency of application, because of the difficulty of spreading small quantities of manure uniformly. This difficulty may, to some extent, be overcome by incorporation of 10% by weight of coir dust in the manure which doubles the bulk of the mixture.

Also in low yielding areas the cost of application becomes a considerable factor in the cost of production and it is doubtful whether applications at intervals more frequent than nine months are in the long run economic. The interval between application at the end of one pruning cycle and the beginning of the following cycle should not exceed nine months.

For yields above 700 lbs. per acre the frequency of application should be increased and intervals between applications reduced to six months. The first application in pruning cycles should normally be given as soon as the fields are ready for tipping and, where fields are vigorous and showing rapid recovery, should not exceed three months. There is no particular objection, especially during weather conditions favourable to manuring, to an application of manure as late as three months before the end of the cycle. In any case the interval between last and first application should not exceed nine months. The frequency of application must be planned according to the normal pattern of weather conditions, and designed to avoid application in very dry or very wet weather.

In cases where yields are very high and well distributed the frequency of application may, with advantage, be increased to four month intervals.

Some elasticity in the frequency of manuring, again so far as is permitted by estate routine, is to be recommended. A period of exceptionally favourable growth, in which exceptional yields have been obtained, should be taken advantage of whenever possible and an extra application of manure given.

The recommendations made in this section should be considered in conjunction with those explained in the sections on method of application and weather conditions.

Method of Application

It must be understood that it is weather conditions, that is to say, warmth, light and moisture, which control the rate of growth of the tea bush. Manure does not stimulate growth, but the lack of available nutrients may limit growth when other conditions are favourable.

The art of manuring is, therefore, to ensure a sufficiency of nutrients whenever the bushes are able to make use of them and must be based on rates of application according to yield and distribution according to root growth.

The ideal is to supply manure as quickly as it is used, so that sufficient nutrients are always available to meet the maximum demands created by the maximum stimulation of weather conditions. In practice the application can only be made at intervals set by cost of production, availability of labour and weather conditions.

Once the intervals of application have been decided upon, and related to monsoon and dry weather periods, the amount put out at each application should be based on the yield actually obtained since the previous application. Some compromise is inevitable since application cannot be varied without consideration of the "kanak" or distribution rate. There are many possible solutions to the problem and the choice must be left to the practical planter.

Since it is desired that the manure should be available to the whole of the feeding root system of the bush it should, when quantities permit, be spread in both rows. Under no circumstances, however, should both rows be deep forked at the same time, as the root breakage may cause a severe check to growth. From the evidence at present available we feel that one deep forking per cycle is sufficient in normal cases and suggest that one row be deep forked at the first application after pruning and the alternate rows deep forked at the following application.

Recent soil studies have indicated that it is undesirable to fork manure in deeply. It should, as far as possible, be scuffled into the top few inches of soil.

Weather conditions during application

The only real objection to manuring in wet weather is the practical difficulty of carrying out the operation. The manure is firmly held by the soil and the danger of leaching or washing out is negligible before nitrification. If the manure is scuffled into the soil it cannot be washed off unless there is serious erosion.

In effect, therefore, the main condition to be avoided is drought, especially alternate wetting and drying of the soil containing the freshly applied manure. Alternate wetting and drying of soil is undesirable in any case and should be, as far as possible, countered by soil cover (including the tea bush) and mulching.

Acknowledging the fact that agricultural operations are mostly a gamble on weather conditions, manuring should be timed, as far as possible, to anticipate sufficient rain to wash the manure down to the permanently moist zone in the soil layer.

General Considerations

First and foremost it must be appreciated that the recommended T.R.I. manure mixtures are not wholly concerned with the replacement of nitrogen, phosphate and potash. For further details the following *Tea Quarterly* articles should be read:—

1. The Mixture as Prescribed. J. Lamb and J. A. H. Tolhurst. *Tea Quarterly*, Vol. XXV, Part III, p. 51.

2. Magnesium and Manganese Deficiencies in Tea. J. A. H. Tolhurst. *Tea Quarterly*, Vol. XXV, Part IV, p. 84.

For further details of the relationship between potash, calcium and magnesium:—

3. Potash Deficiency in Tea. G. B. Portsmouth. *Tea Quarterly*, Vol. XXIV, Part IV, p. 79.

Elements such as calcium and magnesium are so far as is known at present just as essential to the well being of the tea bush as nitrogen, phosphate and potash. In fact the amount of calcium and magnesium present in the tea bush is comparable to the amount of the other three.

To some extent potash, calcium and magnesium are inter-changeable in their nutrient capacity. Tea demands an acid soil and an acid soil is one most probably low in calcium and magnesium. Tea soils are in fact alarmingly low in their calcium and magnesium reserves. It is most probable that potash is at present being supplied in quantities in excess of basic requirements and is usurping some of the functions of calcium and magnesium. Beyond certain limits this substitution of potash for calcium and magnesium may lead to grave difficulties and the ultimate position, especially in high yielding areas where the demand for available nutrients is highest, requires the most careful investigation and co-ordination of chemical and physiological studies.

It must be clearly understood that there is an alarming gap in our knowledge of the requirements for potash, calcium and magnesium and their inter-relationships. It can only be filled by vigorous research.

From the advisory point of view there is no reason, however, why some purely common sense action should not be taken to ensure against calcium and magnesium deficiencies arising in the future, and it is suggested that single applications of ground dolomite limestone at the rate of 5 cwt. per acre should be given, at least to all high yielding tea areas, as a contribution to calcium and magnesium reserves. (*N. B. Soil pH must be checked first. Ed.*)

It is emphasised that this recommendation is not based on any definite scientific evidence and is entirely of the nature of a temporary precaution. No more than one application of limestone should be given to any field until more information becomes available. The ground limestone should have a guaranteed magnesium content expressed as "MgO". It is difficult to make any specific recommendation, but an "MgO" content of the order of 20% should be satisfactory. Ground limestone must not under any circumstances be mixed with other manures but spread separately. There is no reason why ground limestone should not be broadcast at the same time as other manures, but it would be preferable to make the application after the normal mixture has been scuffled in.

There is no particular point in using very finely ground limestone on tea areas and material passing a No. 10 mesh sieve will be suitable.

Trace Elements

One of the reasons for our use of saphosphosphate as the source of phosphoric acid is that it also contains appreciable quantities of some of the trace elements which are just as essential for plant growth as the more familiar major nutrients. A word of warning must be given in regard to these trace elements. They are required by plants in very small amount, hence their name, and if this amount is exceeded harmful effects may follow. It is definitely recommended that commercial trace element supplements should NOT be used, as evidence so far obtained suggests that some tea soils are already supplying an excess of one of the trace elements.

2. YOUNG TEA

Our recommended mixture for young tea is:

T.R.I. 180

Sulphate of ammonia	...	100 parts
Saphosphosphate	...	50 „
Muriate of potash (50%)	...	30 „
		180 „

If 60% muriate is to be used, then the 30 parts quoted above are reduced to 25, the mixture then becoming T.R.I. 175.

In the first year in the field, and with an average rate of growth, the plants should receive two equal doses of ½ ounce each of the mixture, applied at an interval of 6 months. Subsequent doses should be increased in accordance with the age of the plants as below:—

		Size of each dose.
First year	...	½ ounce per plant
Second year	...	¾ „ „ „
Third year	...	1 „ „ „

Where, however, there is very rapid growth, such as may be expected from high yielding clones, then it will probably be advisable to increase the application frequency to once every 4 months, whilst maintaining the size of the doses recommended in the table. This will have the effect of increasing the annual application rate by 50%.

On no account should the mixture touch the stems, and a space of several inches is desirable. A very light scuffling is required.

3. SEED BEARERS

A suitable mixture is:

T.R.I. 530

Sulphate of ammonia	...	300 parts
Saphosphosphate	...	110 „
Muriate of potash (50%)	...	120 „
		530 „

This would become T.R.I. 510 if 100 parts of 60% muriate is used instead of the 50% muriate.

Our suggestion is to apply the manure at 6 monthly intervals, with whatever cultivation is normally adopted, at a rate of not less than 265 lbs. per acre at each application. Higher application rates may well be desirable where large crops of seed are obtained.

MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD AT THE OFFICES OF THE PLANTERS' ASSOCIATION, COLOMBO, ON FRIDAY, 18TH. MARCH, 1955, AT 10-00 A.M.

Present.—Mr. H. S. Hurst (Chairman), Messrs. K. Morford, C.B.E., J.P., U.M., (Chairman, Planters' Association of Ceylon), D. F. Ewen, C.B.E., (Chairman, Agency Section, Planters' Association of Ceylon), Dr. A. W. R. Joachim, O.B.E. (Director of Agriculture), Messrs. R. H. Wickramasinghe, M.B.E. (representing the Minister of Finance), V. G. W. Ratnayaka, M.B.E., M.P., R. C. Scott, C.B.E., J. L. D. Peiris, G. K. Newton, F. Amarasuriya, A. D. McLeod, B. Amarasuriya, C. D. Green and J. Lamb, O.B.E., J.P. (Director and Secretary).

Also.—Mr. J. V. Harbord (T.R.I.).

By Invitation.—Mr. C. F. H. Edwards (Chairman-elect, Agency Section, Planters' Association of Ceylon).

The Chairman welcomed Mr. Wickramasinghe to the Board as the representative of the Minister of Finance, and also Mr. McLeod who had returned from leave.

Letters regretting inability to attend were received from Mr. D. C. L. Amarasinghe, C.C.S. (Tea Controller) and Mr. N. B. Parker.

1. Notice convening the meeting was read.

2. **Minutes of the Board Meeting Held on 21st January, 1955**

The minutes were confirmed, subject to the amendments notified in circular No. A. 10/55, dated March 9th, 1955.

3. **Matters arising out of the Minutes**

(a) **Transfer of the Small Holdings Advisory Service to the Tea Controller.**—A letter from the Permanent Secretary, Ministry of Agriculture and Food, was tabled, intimating that the Minister would be unable to meet the Board's Sub-Committee before May.

(b) **Director's visit to U.K. and West Africa.**—It was pointed out that the minutes stating that the Director had been granted one month's leave of absence was incorrect. Mr. Lamb had been given one week's leave, the remaining period of three week's having been spent on the Board's business.

4. **Membership of the Board**

It was reported that Mr. R. H. Wickramasinghe, M.B.E., had been appointed to represent the Minister of Finance, vice Mr. W. D. Gunaratna, O.B.E., C.C.S.

5. Membership of the Committees

(a) **Finance Committee.**—Mr. Edwards was nominated to fill Mr. Ewen's place. Mr. Ewen was retiring from the island. Proposer:—Mr. Morford. Seconder:—Mr. Scott.

Mr. Peiris was nominated to fill the place of Mr. Hurst, who was now on the committee ex-officio. Proposer:—Mr. Newton. Seconder:—Mr. Green.

(b) **Appointments Committee.**—Mr. J. L. D. Peiris was nominated to fill the vacant place on the Appointments Committee.

6. Minutes of the Experimental and Estates Committee Meeting held on 5th February, 1955

The urgent need to establish the T.R.I. clonal proving stations early was stressed. Mr. McLeod said that the land at Gonakelle Estate could almost certainly be made available, and it was agreed that the Board ask for a 99 year lease. Mr. McLeod said the rent would probably be nominal and he assumed that buildings would, at the expiry of the lease, revert to the landlord. This was agreed.

The minutes were accepted in toto.

7. Minutes of the Standing Committee Meeting held on 18th February, 1955

(a) **Town Survey.**—Mr. Ratnayake reported that he had not yet secured the services of Government surveyors for the survey of St. Coombs. It was agreed that, if Government surveyors could not be obtained early, the work should be offered to a private firm.

Mr. Morford asked if any progress had been made in the negotiations for purchasing land from Mattakelle Estate. Mr. Lamb said that negotiations had not advanced since the death of Mr. Tutein-Nolthenius. It was agreed that this land should be included in the town survey.

(b) **Mr. R. L. Illankoon.**—The Committee's recommendation regarding Mr. Illankoon's salary was accepted. Proposer:—Mr. Morford. Seconder:—Mr. Peiris.

(c) **Leave for Ceylon domiciled Senior Staff.**—The Committee's recommendation for 6 weeks annual leave was accepted; this leave to be non-cumulative and to be taken at the Director's convenience.

The minutes of the Standing Committee were accepted in toto. Proposer:—Mr. Scott. Seconder:—Mr. Green.

8. Appointment of Director

It was decided to appoint Mr. Portsmouth Acting Director until such time as several matters concerning the final appointment were clarified.

9. Any Other Business

(*a*) A request from the Burmese Government, for an official from the Shan State Department of Agriculture to receive a course of training at the Tea Research Institute, was tabled. It was agreed that this officer should be given a six month course, to be arranged when accommodation could be made available.

(*b*) It was agreed that a "scheme of assistance" for replanting tea, which had been requested by the Minister of Agriculture and Food at the Conference, should be prepared by the Agency Section of the Planters' Association, in collaboration with the Low-Country Products Association. A technical appendix in support of the paper would be prepared by the Tea Research Institute if the Agency Section wished.

The meeting ended at 12-15 p.m. with a vote of thanks to the Chair.

Sgd. J. LAMB,
Secretary.

Tea Research Institute of Ceylon,
St. Coombs,
Talawakelle.

MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON, HELD AT THE PLANTERS ASSOCIATION OFFICES, COLOMBO, ON FRIDAY, 3RD. JUNE, 1955, AT 10-00 A. M.

Present.—Messrs. H. S. Hurst (Chairman), K. G. Sinclair (Chairman, Planters' Association of Ceylon), C. F. H. Edwards (Chairman, Agency Section, P.A. of Ceylon), D. C. L. Amarasinghe C.C.S. (Tea Controller), C. D. Green, A. D. McLeod, J. L. D. Pieris, F. Amarasuriya, V. G. W. Ratnayake, M.B.E., M.P., U. B. Unamboowe, O.B.E., M.P., A. R. Cathcart, H. Stacey Hawkes and G. B. Portsmouth (Acting Director and Acting Secretary).

Also.—Messrs. G. A. D. Kehl and J. V. Harbord (T.R.I.).

Letters regretting inability to attend were received from Dr. A. W. R. Joachim O.B.E. Mr. G. K. Newton and Senator E. W. Kannangara, C.B.E.

1. Notice convening the meeting was read.

2. **Minutes of the Board Meeting held on 18th March, 1955**

The minutes were confirmed.

3. **Matters arising out of Minutes**

T.R.I. 500 Fertiliser.—A pamphlet on tea manuring had been prepared and a draft circulated to members. The draft was approved for separate printing and members requested that it should also be published in the *Tea Quarterly*. It was further agreed that it should be translated into sinhalese and tamil.

4. **Membership of the Board**

(*a*) It was reported that under the Tea Research (Amendment) Act, No. 20 of 1955 the membership of the Board had been increased by three. Notice had been received that:—

(i) Senator E. W. Kannangara, Chairman of the Low-Country Products Association, had become an ex-officio member as from April 14th, 1955.

(ii) Mr. U. B. Unamboowe had been appointed to represent the House of Representatives from May 2nd 1955.

(*b*) It was reported that Messrs. H. Stacey Hawkes and A. R. Cathcart had been nominated by the Planters' Association to act for Messrs. R. C. Scott and N. B. Parker respectively during these gentlemen's absence on leave.

(*c*) Mr. Green reported that he would shortly be going on leave and would be absent from the next Board meeting.

The Chairman welcomed all the new members to the Board, and asked the Secretary to write to the Agency Section of the Planters' Association for its nomination of a member to act for Mr. Green.

5. **Minutes of the Experimental and Estate Committee Meeting held on 7th May, 1955**

The minutes of the above meeting and the Visiting Agent's report were accepted in toto. Some discussion took place regarding shot-hole borer. Mr. Portsmouth quoted figures from the annual report of the Tea Controller, which indicated that losses in mid and low-country districts attributable to this pest had reached alarming proportions. He reported that Fisons (Pest Control) might be prepared to second an Entomologist to the Institute to study the problem. So far he had no details of this offer. Members agreed that the situation was serious, and requested the Acting Director to pursue Fison's offer. The Chairman and Acting Director were authorised to accept the offer if it appeared suitable.

6. **Minutes of the Standing Committee Meeting held on May 16th 1955**

(*a*) With regard to the town survey, for which a draft specification had been received from the Surveyor-General, the Chairman agreed to get in touch with the firm of Jonklaas. If this firm could not undertake the work early, it would be put out to tender.

(*b*) In connection with the clonal proving station at Gonakelle Estate, Passara, Mr. McLeod reported that, owing to the recession in the tea trade, the survey of the estate might be postponed till 1956. If this should be decided, he suggested that the Institute might undertake to survey its particular requirements this year at its own expense. This was agreed.

(*c*) The minutes were accepted in toto except for the items dealt with under Staff.

(*d*) The following releases of funds were approved:—

	Rs.
Provision of water supply to Club	550
Board of survey (from 1956 estimate of Rs. 65,000 an advance of)	3,000
Excess of expenditure over provision on tennis court ...	500
Lay out account for upkeep of grounds	10,000
Re-employment of Mr. C. Shanmugam in Entomology Department	2,000
Promotion of Mr. Rajapakse, Assistant at Passara ...	550
Endane fertiliser experiment	12,008
Clonal proving stations	100,000
Engineering department	52,710
Repairs to Pembroke bungalow	5,065
Water supply for Pembroke bungalow	2,500
Relaying roads (3 miles)	48,000
Purchase of motor cycle for Engineering Department ...	3,500
Promotion of Mr. E. N. Perera	500
Rs.	240,883

It was agreed that, in future, when a Committee of the Board recommended the release of further funds, such requests should be put up in the form of supplementary estimates and attached as appendices to the minutes of the Committee.

7. Staff

(a) **Group Insurance Scheme for Monthly Paid Staff.**—A policy offered by the Commercial Union Assurance Company to cover against Personal accident and Specified diseases was considered. The policy would involve payment of an annual premium of Rs. 4,039 to cover the Junior Staff and Rs. 1,773 to cover Small-holdings Staff. The Board asked Mr. Kehl to get details of an alternative policy from Lloyds, and authorised the Acting Director to accept the more attractive.

(*b*) A letter from the Superintendent, thanking the Board, on behalf of himself and his staff, for the 1954 bonuses, was read.

8. Publications

(*a*) Publication of a monograph on Tea Production was approved. The decision as to whether to sell or distribute free was deferred until the cost of production was known.

(*b*) Approval was given to pay a subsidy, if required, for the publication of a monograph on blister blight, which would be produced by the Commonwealth Mycological Bureau.

(*c*) Approval was given for the publication by Mr. Lamb of a number of papers. It was agreed, however, that joint papers on the soil survey would not be published without Mr. Tolhurst's agreement.

There being no other business, the meeting terminated at 12-30 p.m.

Sgd. G. B. PORTSMOUTH,
Acting Secretary.

Tea Research Institute of Ceylon,
St. Coombs,
Talawakelle.

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